PRIVATE AND CONFIDENTIAL

RESEARCH DEPARTMENT

VISIT TO VIENNA, HAMBURG AND COLOGNE

NOVEMBER 1955

Report No. A-041

(1956/12)

THE BRITISH BROADCASTING CORPORATION
ENGINEERING DIVISION

RESEARCH DEPARTMENT

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SUMMARY

For the purpose of studying technical and operational problems connected with microphones, loudspeakers and related equipment used in broadcasting, a visit has been made to Vienna, Hamburg and Cologne. In addition to studio centres in the three cities, the visit included the factory of the Akustische und Kinogeräte Gesellschaft in Vienna and the Central Technical Establishment of the Nordwestdeutscher Rundfunk* in Hamburg.

1. INTRODUCTION.

The visit to be described, which was undertaken in company with Mr. R.S.C. Gundry of Operations and Maintenance Department (Sound), included the factory of the Akustische und Kinogeräte Gesellschaft (A.K.G.), studio centres in Vienna, Cologne and Hamburg, together with the Central Technical Establishment of the Nordwestdeutscher Rundfunk* (N.W.D.R.) which is also in Hamburg.

As far as the Research Department representative was concerned, the principal objects of the visit were:

a. To study German and Austrian practice in the design, manufacture, operation and maintenance of microphones, with particular reference to the electrostatic type now being imported from the Continent.

b. To discuss technical and operational problems in the audio-frequency field with the personnel immediately concerned and to obtain advance information on new developments.

The timing of the visits was as follows:

Vienna.	17th, 18th and 19th November:	A.K.G. factory, State Opera House and Broadcasting studios.
Hamburg.	21st, 22nd and 23rd November:	Laboratories and studios of N.W.D.R., Musikhalle and State Opera House.
Cologne.	24th November:	Broadcasting studios and test rooms of N.W.D.R.

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*As a result of a reorganisation which took place in the German broadcasting system on 1st January 1956, the N.W.D.R. has now ceased to exist in its original form and some changes have taken place in the Central Technical Establishment at Hamburg. Reference in this report to the organisation and staff of these bodies may not be applicable to the new régime.

For the sake of clarity, the information gathered in the course of the visits is given, not in chronological order, but under the appropriate subject headings.

2. MICROPHONES.

2.1. General.

In North Germany and in Austria, electrostatic microphones are used almost exclusively for indoor work; certain German microphones of this type have been used out of doors also though for this purpose moving-coil microphones are the most common. Little interest is taken in the ribbon and piezo-electric types.

In Germany, most of the electrostatic microphone designs originate in the N.W.D.R., but are manufactured by the firms of Neumann and Hiller. In Austria, all microphones of this type used in broadcasting are designed and manufactured by A.K.G.; it should be noted that this firm is associated with the Siemens organisation and that some of its products are also marketed under that name.

The moving-coil microphones used in the N.W.D.R. are designed and manufactured by Laboratorium Wennebostel (Labor) in Hanover and the corresponding Austrian types by A.K.G. All these microphones have moving coils wound to the Continental standard microphone impedance of 200 ohms instead of the 20 to 30 ohms usual in Britain and no matching transformers are therefore necessary. In the case of the A.K.G. microphones, the fine gauge wire required for these high impedance windings has to be imported from Switzerland.

The mainstay of studio broadcasting in Vienna is now the A.K.G. type C.12[1], while in Hamburg and Cologne the corresponding microphone is the Neumann type M.49[2]. Both the C.12 and M.49 have remotely controllable polar characteristics. In Germany, the M.59[3] miniature cardioid microphone, the corresponding "omnidirectional" pressure type M.60 and the partially-directional pressure type M.50[2] are also employed, though for reasons given later it appears likely that the latter will fall into disuse before long. There is no lip microphone corresponding exactly to the B.B.C. types L.1 and L.2; a moving-coil pressure-gradient instrument type MD.4*, of somewhat inferior performance, is used for close talking in noisy surroundings and an improved version of this, the type MD.42, is coming into service.

Other types of microphone which are still in the experimental stage will be dealt with in Section 8.

2.2. Manufacture.

As already indicated, neither the German nor the Austrian broadcasting organisations manufacture moving-coil microphones and while A.K.G. have under development two new instruments of this type, the visit to the firm's works revealed little that was new in the technique of production. The design and manufacturing information obtained on the present occasion was therefore confined to electrostatic microphones.

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*A specimen of the Labor type MD.4 microphone has recently been tested in Research Department. Apart from the price, which is relatively low, this instrument offers no advantage over the B.B.C. type L.2 microphone, to which it is in some respects inferior.

It is clear that the principal practical difficulties in the manufacture of electrostatic microphones are concerned with the mechanical properties of the diaphragm material.

The diaphragm of microphones such as the M.59 is of nickel or of aluminium alloy 5 microns thick. These materials are liable to form minute crystals on the surface. Such growths, if unchecked, may cause a short-circuit in the narrow gap between the diaphragm and the stationary electrode; for this reason a protective coating of lacquer or gold is frequently applied. Experiments are now in progress with a new plastic diaphragm material capable of withstanding the highest temperature (80°C) for which the present M.59 microphone is designed and it may thus be possible to avoid the use of metal altogether.

Plastic diaphragms for microphones such as the M.49 have a thickness of the order of 10 microns and are produced as follows:

A predetermined quantity of the diaphragm material in liquid form is allowed to fall drop by drop on to a highly polished glass plate in a space enclosed by a metal ring, some 8 cm (3 in.) in diameter. The process is carried on at a controlled temperature in a glass-fronted cabinet provided with two holes just large enough to admit the operator's arms. After three days, the plastic sheet, now set and adhering to the metal ring, is separated under water from the glass plate, and dried in a vacuum for a further fourteen days. The conducting coating of gold is then deposited by evaporation; a certain wastage is unavoidable at this stage, as the diaphragm may blister in the process. The completed diaphragms, each still attached to its ring. are then ready for use.

The diaphragm material for the Austrian microphone C.12 is imported from Switzerland with the conducting layer already deposited.

Microphones of the M.49 type suffer from ageing of the plastic diaphragm, which after a time becomes too stiff. Specimens manufactured during the last 2½ years are fitted with diaphragms of more stable material and it is hoped within the next year to achieve a further improvement in this direction.

It was not possible in the time available to see the process of fitting the diaphragms to the microphones at the N.W.D.R., but the corresponding operation was witnessed at the A.K.G. factory. A circular area of diaphragm material a little larger in diameter than the completed microphone is first tensioned in a jig, and finally cemented to a ring which is attached to the microphone assembly by a number of small screws. The method of observing the tension of the material is to allow a small bead to fall from a height of a few inches on to the diaphragm, and to compare the pitch of the sound thus excited with that of a similar, but calibrated standard. Unlike the metal diaphragm type of electrostatic microphone, the plastic diaphragm type does not require to be assembled in a dust-proof room, as the conducting coating is on the outside, and thus does not depend on the air gap for its insulation from the fixed electrode.

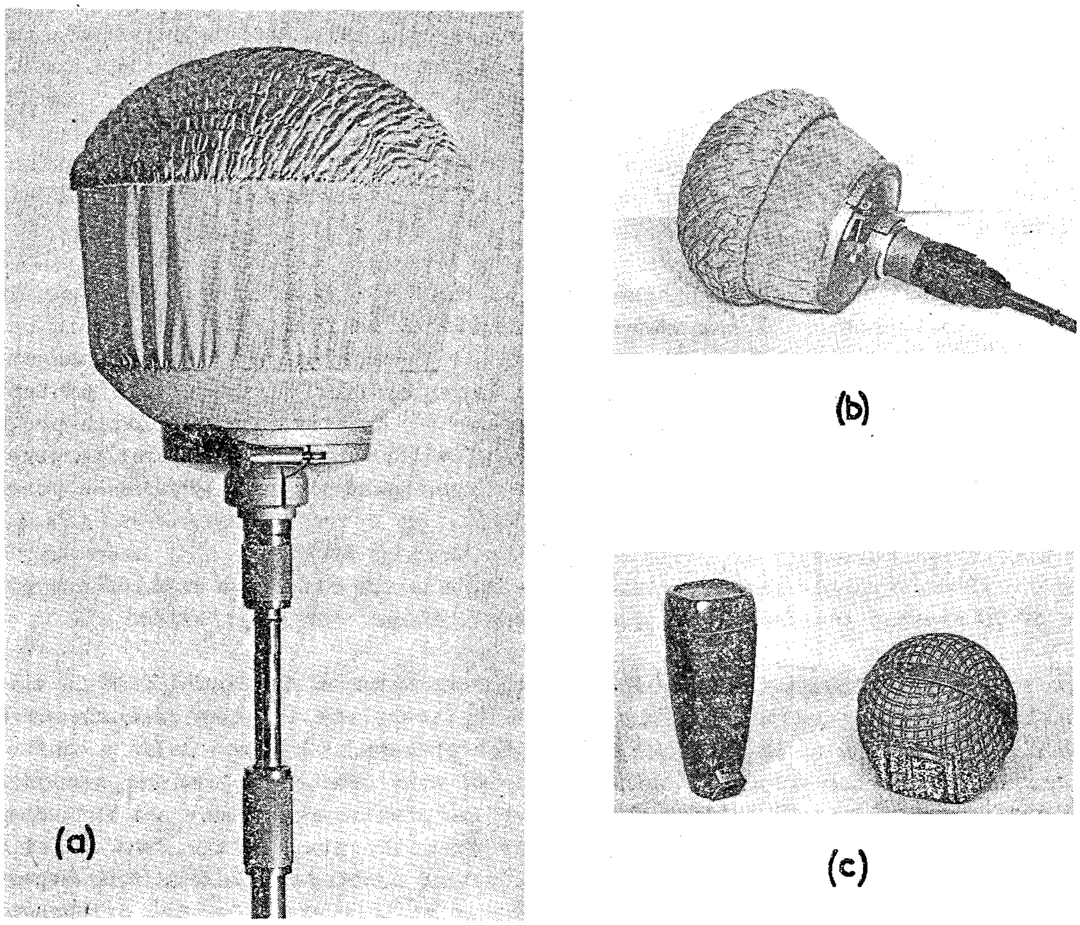

**Fig. 1 - (a) 25 cm (10 in.) collapsible microphone wind shield (N.W.D.R.)
(b) 12 cm (4¾ in.) collapsible microphone wind shield (N.W.D.R.)
(c) Labor microphone type MD.21 with wind shield**

2.3. Wind Shields.

The N.W.D.R., like the B.B.C., has found it necessary to investigate means of protecting microphones from wind. The small shields already supplied to the B.B.C. for use with microphones such as the M.59, are primarily intended to permit close talking; their function however involves a certain attenuation of the low-frequency response accompanied by distortion of the polar pattern, effects which in other applications may be undesirable. The general-purpose wind shields used by the N.W.D.R. are, by British standards, rather large. Figs. 1(a), 1(b) and 1(c) show three types which are in production; others are still in the experimental stage. Shields (a) and (b) are both collapsible for transport and have a domed top covered by fabric quilted with elastic thread; this is claimed to be very effective in deadening the impact of rain drops. Type (a) which has a diameter of 25 cm (10 in.) is intended for wind speeds up to 16 m/sec (5·3 ft/sec) and is provided with adaptors to fit any of the microphones used. Type (b), 12 cm (4¾ in.) in diameter, is intended for wind speeds up to 8 m/sec (2·6 ft/sec) and fits small electrostatic and moving-coil microphones. Type (c) is about 10 cm (4 in.) in diameter; it is designed for use with the Labor moving-coil microphone type MD.21 (also shown in the figure) for O.B. work out of doors, also at wind speeds up to 8 m/sec.

2.4. Contribution of Microphones to the "Spuckeffekt".

Some concern has been caused in Germany by the occurrence in F.M. broadcast reception of a form of distortion characterised by a spitting sound accompanying heavy modulation and hence known as the "Spuckeffekt"[4]. The main cause of the trouble is stated to lie in the use by the public of receivers having an inadequate band-width and in some cases not correctly tuned. A contributory cause is, however, the use by the broadcasting organisation of microphones having a rising characteristic at high frequencies; the high-frequency components of the signal are thus increased in level and the application of pre-emphasis results in excessive modulation with certain types of programme. To avoid this effect it has been proposed to apply equalisation, either by an electrical network or, in the case of the smaller types such as the M.59 and M.60, by an attachment placed over the front of the microphone itself. The attenuation required to correct the rise in microphone response amounts to some 6 dB to 8 dB at 10 kc/s and it is therefore surprising that the N.W.D.R. has not thought equalisation necessary for other reasons than for the avoidance of overmodulation.

2.5. Testing and Maintenance.

In Britain, the studio microphones in use for the last two decades have been principally of the pressure-gradient ribbon type, which requires but little specialised equipment for maintenance or routine test; the manufacture of electrostatic microphones was virtually abandoned in the mid-thirties at an early stage of development and nearly all instruments of this type used in this country since that time have been imported from the Continent. In view of the recent growth in the number of these imported instruments and the unaccustomed testing and maintenance problems which they bring, special interest attaches to the practices followed in their countries of origin.

In the Austrian broadcasting organisation, which has not yet recovered from the effects of war and foreign occupation, there are no facilities for microphone response measurements. However, nearly all the microphones used, both electrostatic and moving-coil, are manufactured locally by A.K.G. and acceptance tests are carried out at the factory in the presence of a representative from the Funkhaus. The pre-war arrangement, which is to be revived when conditions return to normal, involved test facilities common to both maintenance and development departments.

The A.K.G. microphone laboratory has a small lagged room with a working space approximately 3 m × 1·8 m × 2 m high, (10 ft × 6 ft × 6 ft 6 in.) the maximum depth of the acoustic treatment being about 0·8 m (30 in.); two similar rooms are provided in the works for production testing. The electro-acoustic equipment consists in each case of the usual pressure-type standard microphone mounted beside the microphone under test at about 0·6 m (2 ft) from a loudspeaker and controlling the sound level by means of an A.G.C. circuit. This system of measurement, when applied to microphones having a cardioid or figure-of-eight polar pattern is subject to considerable error at low frequencies, at which the requirement for a plane progressive sound wave cannot be even approximately met. The arrangement described is adequate for some types of production test but it is surprising that no additional facilities, such as a travelling wave duct, have been provided for the development laboratory. The electrical equipment used for microphone response measurement in the laboratory is of the well-known Brüel and Kjaer type; in one of the production testing rooms, similar apparatus constructed by A.K.G. is used, while in the other, a C.R.O. display of frequency characteristic is provided to permit rapid adjustment of individual microphones. At the time of the visit no means were provided for tracing polar patterns but it is learned that equipment for this purpose has since been installed.

In the Central Technical Establishment of the N.W.D.R. in Hamburg, the methods of microphone response measurement are similar in principle to those practised in the A.K.G. laboratory. Provision is made for polar response measurement but again there is no travelling wave duct; here, however, the engineers concerned are more aware of the limitations of their equipment. The lagged room associated with the microphone laboratory is somewhat larger than those at the A.K.G. works, but smaller than that at Kingswood Warren; the acoustic treatment appears to be no more than 0·5 m(20 in.) deep. A smaller lagged room is available elsewhere for rough tests carried out for routine maintenance purposes, but there is no hard and fast division of function and the main room is being used for both maintenance and development work.

The only novel feature of the equipment for measuring microphone response is the use of a magnetic recorder to reproduce, at the input to the loudspeaker amplifier, the signal recorded at this point during an earlier frequency run during which the sound field was controlled by the standard microphone. This artifice allows a microphone to be tested by the substitution method without the labour of subtracting two response curves; the accuracy and frequency range of the measurement are necessarily limited by the characteristics of the recording system.

The frequency at which routine checks of apparatus must be made in the N.W.D.R. is determined by a statistical study of the fault records; the interval between tests is that corresponding to a fault probability of a few per cent.

Microphone tests include a response check with octave bands of white noise against a pressure-type standard microphone. This check, which can be carried out in a live room, does not give the correct low-frequency response of figure-of-eight or cardioid microphones nor does it cover the polar pattern, the latter being taken on trust on the strength of the frequency response. Each microphone is given a routine test once a month; as there are now 250 microphones to be dealt with at Cologne, the testing here occupies the full time of one man.

It is perhaps appropriate to record at this point that it is a common practice in the N.W.D.R. for microphones, when not in use, to be removed from the studio and placed for safe keeping in a cupboard provided for that purpose in the cubicle. In so far as this procedure may be taken to indicate a generally cautious attitude on the part of operating staff, it seems likely that microphones in the N.W.D.R. are spared some of the rougher treatment which their British counterparts are expected to withstand.

2.6. Operation.

2.6.1. Microphones in Studios.

In Vienna and Hamburg, as already indicated, the main studio microphones have remotely controllable polar characteristics; the cardioid and figure-of-eight patterns are mostly favoured. At recording sessions of light opera in the orchestral studios of Vienna and Cologne, it was noted that soloists and small groups of singers were being picked up by microphones at very close range; the result, as heard on the cubicle loudspeaker, was very much as expected. In one case, a tenor soloist had been placed only about 30 cm (1 ft) from his microphone, the intention, it was stated, being to match the acoustics of the sung items to those of the spoken dialogue recorded separately in a drama studio.

In Cologne, considerable use is made of the type M.50* microphone, a pressure-type instrument designed to give a rising axial response at high frequencies but a uniform response to sound at random incidence. It is emphasised in the literature[2] that the M.50 microphone is intended only for long-range pickup. It was therefore with some surprise that the contrary practice was found to apply in Cologne, where microphones of this type are used for close pickup of individual brass instruments in a dance band and, as in the case already cited, at as little as 30 cm from an operatic soloist. The fact that the resulting over-emphasis at high frequencies is not objected to is probably due to the fact that most of the cubicles in Cologne are equipped with old-type monitoring loudspeakers which have a certain loss in response at high frequencies; this view received indirect support by a statement from one of the studio managers regarding a supposed high-frequency loss in the alternative microphone M.49. In Hamburg, where the newer "omnidirectional" loudspeaker, with an increased high-frequency response, is in more general use, the type M.50 microphone is seldom employed; it seems reasonable to suppose that similar conditions will eventually be established in the other studio centres of the N.W.D.R.

2.6.2. Microphones in Theatres.

The most striking departures from British practice in the use of microphones were observed in the State Opera Houses in Vienna and Hamburg, where concern for the good acoustics of the transmission appears to outweigh the usual aesthetic requirement that technical equipment should be kept out of sight. In Vienna, for example, a microphone was seen hanging immediately in front of, and some 3 m (10 ft) below the top of, the proscenium arch; during parts of the performance, the microphone and its lead, which lay in the beam of one of the spotlights, stood out, brilliantly illuminated, in the darkness. In Hamburg, although the microphones were not in place at the time of the visit, it is understood that a number of microphones is sometimes suspended above the stage. It is not suggested that either of these positions is ideal; the use of microphones above the heads of the performers is known to be unsatisfactory. However, the fact that the microphones were allowed to be so conspicuous suggests a more accommodating attitude on the part of the Austrian and German Opera House authorities, or a more militant approach by the broadcasting engineers, than is customary in Britain; subsequent enquiries tended to support the latter view. A further example of the relative freedom allowed in the placing of microphones in the Vienna Opera House is given by the photograph of Fig. 2, which was taken on the occasion of the ceremonial opening. The microphones at the front of the stage are of a type newly developed by A.K.G.; further reference to these will be made in Section 8.

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*A microphone of this type has already been tested in the B.B.C. and rejected on account of the unpleasant quality which it produced in the upper-frequency range.

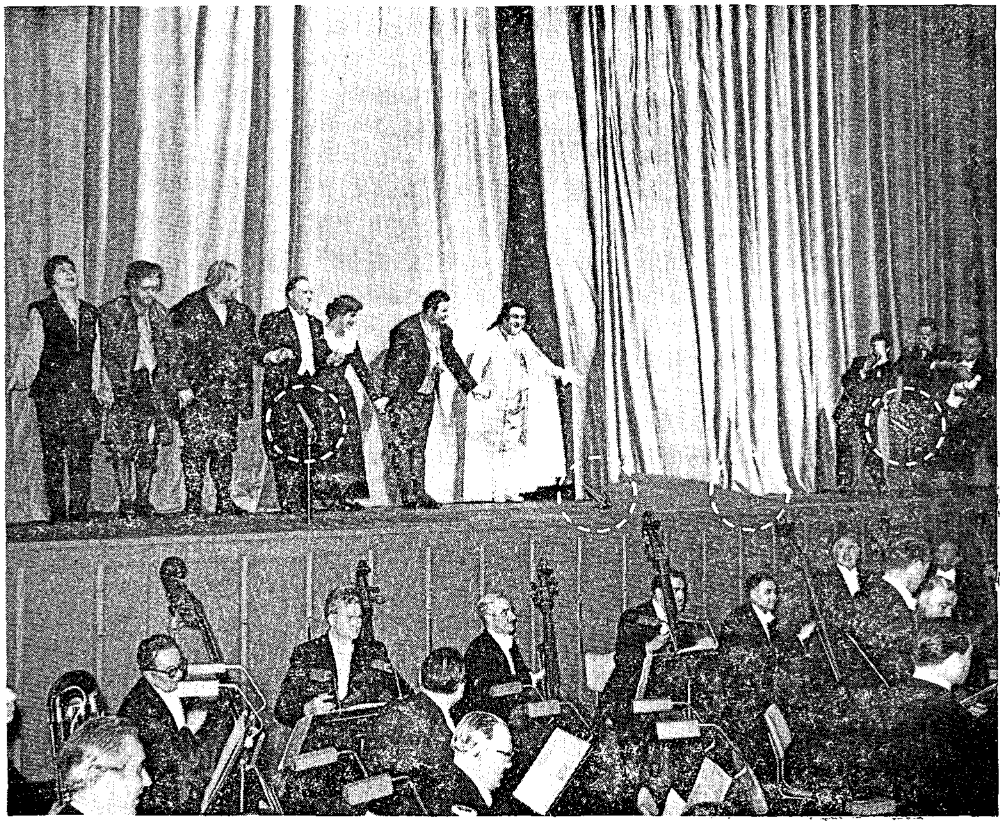

Fig. 2 - Vienna State Opera House. View of stage showing disposition of microphones

3. LOUDSPEAKERS.

3.1. General.

All the monitoring loudspeakers seen on studio premises in Austria and Germany employed two or more cone units. In the Vienna Funkhaus, the standard monitoring loudspeaker consists of two nominally identical units, each of about 20 cm (8 in.) chassis diameter, mounted, together with an 8 watt amplifier, in a closed cabinet some 1·4 m (4 ft 6 in.) high. The volume at the rear of the loudspeaker is 0·18 m^3 (6 ft^3); the whole assembly is manufactured by a local firm, Henry-Radio.

In Hamburg, the new "omnidirectional" monitoring loudspeaker, which consists of an assembly of twelve small high-frequency cone units arranged in spherical formation, together with a single low-frequency cone unit of 30 cm (1 ft) diameter, was heard in action in the laboratory and in a cubicle. This equipment, which will be discussed later, has not yet replaced the earlier designs and the loudspeakers most frequently encountered on the present occasion were the type 05, illustrated in Fig. 3, and a slightly larger type 06 which is employed where a higher power output is required. A third, still larger, loudspeaker is used for playback in studios; a brief reference to this will be made later.

The type 05 loudspeaker employs three low-frequency units of about 20 cm (8 in.) chassis diameter similar in type but having fundamental resonance frequencies of 40 c/s, 50 c/s and 60 c/s. Two high-frequency units of about 16 cm (6 in.) chassis diameter are mounted side by side but facing some 30° or 40° right and left of the main loudspeaker axis; the crossover frequency is 2 kc/s. The cabinet, which is some 1·4 m (4 ft 6 in.) high and is perforated at the rear with a large number of slots, also contains a 10 watt amplifier. The axial frequency response is stated to be within ±5 dB from 120 c/s to 7 kc/s, with the response at 35 c/s and 13 kc/s 10 dB below the mean mid-band level. On the few occasions on which it was possible to hear the type 05 loudspeaker unit in action, the programme material did not allow the extreme bass response to be subjectively assessed, but the upper frequency range was estimated to extend above that of the LSU/10.

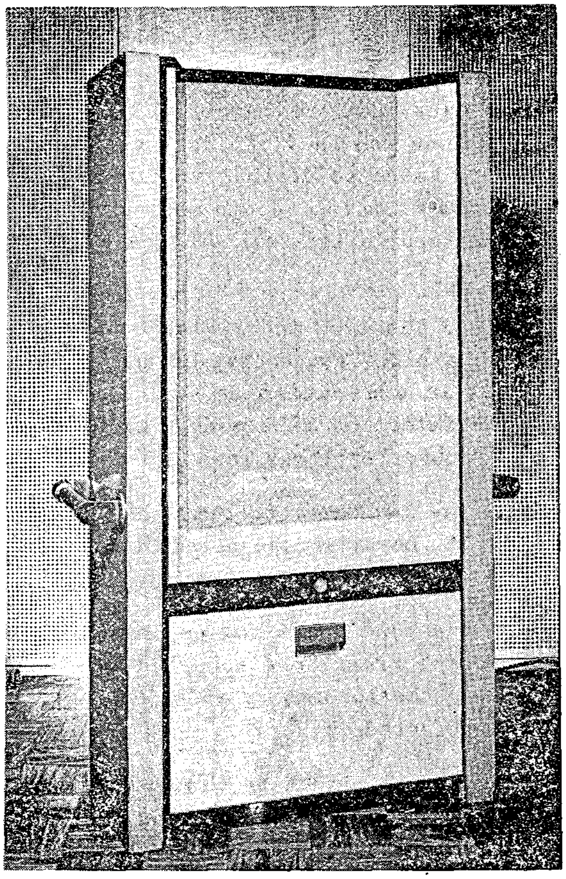

Fig. 3 - Monitoring loudspeaker unit type 05 (N.W.D.R.)

Type 06 loudspeaker is slightly larger than the type 05, has a total of 8 cone units and an amplifier of higher power rating. The frequency range is stated to be slightly greater at both ends of the scale than that of the type 05; there was no opportunity to hear one of these loudspeakers.

In addition to the loudspeakers employed for the monitoring of programmes, some larger versions of the twelve-sided "omnidirectional" assembly previously referred to are provided in studios for play-back or for sound reinforcement. Where high-quality music reproduction is required, dual elliptical units 32 cm × 21 cm (12½ in. × 8¼ in.), incorporating an independent circular cone radiator for high frequencies, are used and a separate loudspeaker of conventional type is employed for the frequency range below 200 c/s; in other cases, single cone units of 20 cm (8 in.) diameter are considered adequate and the twelve-sided assembly is used by itself.

3.2. N.W.D.R. Omnidirectional Monitoring Loudspeaker.

The omnidirectional monitoring loudspeaker, to which brief reference has previously been made, has already been described in the literature[5]. It may nevertheless be well to recall here that the frequency of the crossover between the low and high-frequency units is at about 400 c/s and that the 25 watt amplifier which feeds the loudspeaker is preceded by an equaliser amplifier; the latter contains a number of resonant circuits intended to compensate for corresponding features in the radiating system and produces a considerable high-frequency pre-emphasis. One of these loudspeakers, minus the cabinet for the low-frequency unit, was ordered by Research Department in 1953 for test. The performance of this specimen, which for convenience will be referred to as the 1953 model, was found to fall short of expectations and in visiting the N.W.D.R. laboratory at Hamburg, the opportunity was therefore taken to discuss with Dr. Harz, the designer, and others, those features of the equipment which appear most open to criticism. The substance of the discussion is summarised in the following paragraphs.

a. In the 1953 model, the equaliser amplifier was very prone to overloading at high frequencies on account of the pre-emphasis employed; in addition, the cone units in the spherical radiator showed marked non-linear distortion at a number of discrete frequencies, even when the reproduced sound level was low.

The tendency to overloading of the equaliser amplifier was agreed by Dr. Harz, who supplied details of a modified amplifier circuit designed to overcome this difficulty.

The cone units now employed in the spherical radiator are of a different type from those supplied to the B.B.C. and, judging from the performance of the laboratory model demonstrated, are free from the non-linear effects referred to.

It was learned by chance from another specialist engineer in N.W.D.R. that the increased distortion on programmes which became audible on the first introduction of the new loudspeaker had been found to originate partly in the loudspeaker itself; it would therefore appear that the B.B.C.'s experience with this instrument is not unique.

b. Most of the high-frequency cone units in the 1953 model exhibited a sharp peak in response in the region of 9 kc/s. An attempt had been made to remedy this state of affairs by including in the equaliser amplifier an additional sharply tuned resonant circuit not used in the original design; as is common in such cases, however, the correction, judged by ear, was not fully effective. The cone units now employed are stated to be free from the 9 kc/s peak and the quality of reproduction heard in the laboratory lent support to this claim. The introduction of yet another type of unit, having a higher sensitivity, is contemplated.

It had been noted with some surprise that the hollow shell on which the high-frequency cone units are mounted is devoid of any acoustic absorbent material. Dr. Harz maintained that all effects arising from this lack of acoustic damping are adequately compensated by the electrical equalisation provided; the subjective effect produced by the loudspeaker however, gives grounds for doubt on this point.

c. Difficulty had been experienced in reproducing in the 1953 model the intended bass response, as the acoustic treatment of the enclosure had not been accurately specified; this lack of information was remedied by inspection of a loudspeaker in the laboratory. It was learned, however that the low-frequency response curve of each loudspeaker is now adjusted, by varying the circuit elements in the equaliser amplifier, to suit the acoustics of the environment.

From the foregoing it will be seen that the original design of omnidirectional monitoring loudspeaker described in the literature has undergone some modification and that further changes may later be introduced; the evolutionary process appears to have included one or two retrograde steps, but these have since been retraced. The performance of the models heard in November 1955 was an improvement on that of the 1953 version, though a certain characteristic lower-middle frequency colouration, to which exception was taken in the earlier model, persists and it may be that too much reliance is still being placed on resonant electrical circuits to correct the characteristics.

4. STUDIOS.

Most of the studios in the Vienna Funkhaus are of old design and do not show any features of great technical novelty. Much use is made of slotted plywood backed with glass wool and, in one case, of tapestry stretched over thin wood panelling. Ceiling absorber units consisting of boxes of varying depths covered with Masonite are used in some studios; the ceiling of the main orchestral studio is coffered. Many of the studio floors are covered with linoleum, the sound absorption which would otherwise be provided by a carpet being made up elsewhere. Reverberation-time characteristics of these studios, and in some cases of the associated cubicles, supplied by Dr. Skalar, Technical Vice-Director of the Austrian broadcasting organisation, are reproduced in the Appendix.

Three reverberation rooms are provided; apart from their normal use for effects, these are sometimes employed to modify string tone in musical programmes.

Most of the studios and associated technical areas visited in Hamburg and Cologne have already been described in N.W.D.R. publications and call for no detailed comment here. An exception must be made in the case of the large orchestral studio No. 10 at Hamburg, which has been recently modified. The ceiling has been rebuilt in the form of a saw-toothed structure of some 2 m (6 ft) pitch; in addition, the backs of the first four rows of seats provided for the audience are constructed with thin plywood at front and rear, thus forming a hollow space varying in depth from top to bottom. The central floor area, which was originally solid, is now covered with wood over a hollow space 30 cm (1 ft) deep; the new floor is claimed to be "non-creaking".

Technical information on the modified studio No. 10 has not yet been published but a reverberation time curve, supplied by the N.W.D.R., is reproduced in the Appendix.

At the time of the visit, the whole of the central floor area of the studio was occupied by the orchestra, so that the reflecting "apron" provided in British studios was absent.

On either side of the orchestra, with its back against the side wall of the studio, was placed a loudspeaker some 1·2 m (4 ft) high and 1·5 m (5 ft) wide, containing, as far as could be seen, two 40 cm (16 in.) and two 20 cm (8 in.) diameter cone units; these loudspeakers are used for play-back of orchestral music. A large "omnidirectional" loudspeaker array of the type already described was hung over the audience seating; this was used either in conjunction with the main loudspeakers for play-back or for sound reinforcement in cases where a soloist could not otherwise be properly heard by the studio audience.

A practical example of the use of the large twelve-sided play-back loudspeaker for speech reinforcement was seen in Studio 2 at Cologne[6], where a rehearsal for a panel game was in progress. The loudspeaker was suspended at a height of some 3 m (10 ft) above an area intended to seat an audience of 200. In these circumstances, the use of an "omnidirectional" loudspeaker naturally increased the tendency of the system to howl back; and it was observed on this occasion that with the circuit apparently not far short of the singing point, the loudspeaker level obtained from the members of the panel, each of whom spoke at 40 cm (16 in.) to 60 cm (24 in.) from a cardioid microphone, left much to be desired.

5. CUBICLE AND CONTROL ROOM EQUIPMENT.

The cubicle and control room apparatus in Hamburg and Cologne is of the well-known German type and requires no description here. In Vienna, much of the corresponding equipment is of obsolete design and is in process of being replaced by new installations similar to, though not identical with, the German pattern.

In both Austria and Germany, microphone mixing is carried out at high level and microphones operate under substantially open-circuit conditions. In both countries it is common practice to limit the transmitted frequency range by high- and low-pass filters having nominal cut-off frequencies of some 40 c/s and 15 kc/s respectively. The removal of frequencies below 40 c/s is intended to avoid rumbles due, for example, to solid-borne vibrations which it is not economic to eliminate in the studio. The high-frequency restriction is necessary to prevent the accidental transmission of ultrasonic frequencies generated in the magnetic recording equipment.

In Germany, consideration is being given to the possibility of adopting a standard form of bass cut to be applied to transmissions of news and talks, the object being to avoid the unnaturally low-pitched effect which results when the voice is reproduced at a sound level higher than that of the original. Attenuations of 2 dB at 400 c/s and 11 dB at 100 c/s have been suggested; at the time of the visit, however, the proposal had not been implemented.

All the remarks in this section refer to the sound services. It was not possible in the time available to visit any television studios.

6. O.B. EQUIPMENT.

The O.B. vans seen in Hamburg are constructed as mobile control rooms and equipped for both magnetic recording and line transmission.

The control and mixing arrangements are similar in principle to those adopted in the studio; mixing takes place at high level.

To ease the technical requirements for temporary circuits, O.B. lines are fed at a level 6 dB higher than the normal S.B. lines.

The larger O.B. vans have in addition to the main loudspeaker an auxiliary loudspeaker used for pre-fade listening. High-quality headphones are also used for control.

Some of the later sound and television O.B. vans are fitted with a modified form of the omnidirectional wide-range loudspeaker referred to in Section 3, the middle and high-frequency radiator being hemispherical in form and mounted on the ceiling; none of these vans was, however, available for inspection at the time of the visit.

7. LINES.

To illustrate their views on the technical requirements of a modern S.B. system, the N.W.D.R. in Hamburg demonstrated, by a series of magnetic recordings, the effects of phase distortion and of limitation in high-frequency response on music lines. Details of these tests are given in a recent paper by Belger, Pavel and Rindfleisch[7]; the essentials may be briefly summarised as follows.

The lines used for the demonstration were of two types, referred to as type I and type II, having nominal frequency ranges of 30 c/s to 8·5 kc/s and 20 c/s to 16 kc/s respectively. For each type of line, a loop approximately 1000 km in length was used. High-grade magnetic recording equipment was employed to record the output and to replay it round the loop; by repeatedly dubbing the signal in this way, the effect of 2000, 3000, 4000 or 5000 km of line was obtained, though in presenting the results for subjective assessment, a recording made by an equal number of dubbings without the line loop was provided for comparison.

The test material was of two kinds, chosen to show the effects of both attenuation and phase shift at the upper and lower ends of the frequency range. The demonstration clearly illustrated the improvement brought about by the application of phase equalisation at high frequencies to lines of type I, together with the fact that lines of type II could be used in lengths up to 5000 km without need of such correction. The low-frequency tests were of particular interest, as they showed little sign of those amplitude distortion phenomena which on the British S.B. system, overshadow the effects of low-frequency phase distortion.

The demonstrations of frequency band limitation did not provide any new information but illustrated in striking fashion the contribution of the components between 9 kc/s and 11 kc/s to the sound of certain musical instruments.

By courtesy of Dr. Rindfleisch, Technical Vice-Director of the N.W.D.R., arrangements were made for a copy of the demonstration recording to be provided for loan to the B.B.C. and this undertaking has since been implemented.

It was noted that in Austria, microwave links are being used to supply programme to the V.H.F. transmitters, thus avoiding the embarrassment caused by the combination of good broadcast reception with bad line transmission. Similar links are used in Germany, but only as a standby in case of line failure.

8. RECENT DEVELOPMENTS.

8.1. Artificial Reverberation.

In Hamburg the opportunity was taken of attending a lecture which was being given by Dr. Kuhl of the Rundfunk Technisches Institut (R.T.I.), Nuremberg, on a novel type of mechanical reverberation device. The reverberant element developed by the R.T.I. consists of a steel sheet 1 m (3 ft 4 in.) square and 1 mm (0·04 in.) thick suspended vertically by a number of tightly stretched thin wires attached to the edge; only flexural wave motion is utilised. The incoming signal is applied to a moving-coil driver unit located at the centre of the sheet while the reverberant output is picked up by a piezo-electric element applied to another part of the surface. The reverberation time is controlled by a sheet of sound absorbing material mounted parallel to and at a short distance from the steel sheet; variation of the spacing between the two alters the damping and hence the reverberation time, which can be varied in this way between 1 second and some 10 seconds.

Photographs of the mechanical reverberation equipment were shown and the performance demonstrated by magnetic recordings. The quality of the reverberation obtained was impressive; although various kinds of colouration were present, amplitude flutter had been reduced to a point at which the residual effects might have been attributed to the recording system, which gave a certain amount of trouble during the demonstration.

The lecture, which took place in the Institut für Angewandte Physik, was followed by a lively and critical discussion by an audience of some 50 people, most of them connected with the N.W.D.R. Copies of Dr. Kuhl's paper are not yet available.

8.2. Press Conference.

The visit to Hamburg also coincided with one of the periodic press conferences held by the N.W.D.R. Apart from a few sessions held for the benefit of the technical journals, the business dealt with at these conferences is mostly of a non-technical character; the occasion in question was exceptional in that technical equipment, some of it still at the prototype stage, was being demonstrated to a non-technical audience.

The proceedings, which lasted about 1¾ hours, were completely informal, the assembly, some 70 persons in all, being accommodated at a number of round tables, at which a supply of appropriate refreshments was unostentatiously maintained. At one of these tables were seated various members of the N.W.D.R. staff — including Dr. Nestel, Technical Director of the N.W.D.R. and Dr. Kösters, the engineer in charge of acoustics research — who in turn rose to address the company or to answer questions.

The meeting opened with a statement by an N.W.D.R. spokesman on administrative matters of only local interest. There followed a dissertation on the technique of obtaining and recording topical news material, leading up to a series of demonstrations of modern technical equipment designed to facilitate the radio reporter's task. Finally, certain potentialities of topical broadcasting were illustrated by a series of recordings of events or interviews, some of which had been made in harrowing circumstances involving personal tragedy; the conference then ended with a discussion on the ethical and legal problems arising in such cases.

Some of the items of technical equipment displayed have been dealt with in N.W.D.R. publications; but for completeness, a brief description is given of each.

1. Portable battery operated magnetic recorder type R.85.

   Tape speed, 7½ in./sec (19 cm/sec).
   Dimensions, 13·5 cm × 26·5 cm × 38·5 cm (5¼ in. × 10½ in. × 15 in.).
   Weight, 9·8 kg (22 lb).

   A technical description of the R.85 has already been published[8]; a later version, type 85a, has facilities for recording a pilot frequency for synchronising with film[9].

2. Battery operated O.B. amplifier type V.79 using transistors throughout.

   Two microphone channels are provided, with high-level mixing.

   Dimensions, 31 cm × 18 cm × 12 cm (12¼ in. × 7¼ in. × 4¾ in.).
   Weight, 6 kg (13 lb).

   A technical description has been published[10].

3. Noise-cancelling microphone.

   This is an M.59 cardioid microphone modified by increasing the tension of the diaphragm to give a low-frequency loss, with the addition of a small "close-talking shield" giving protection against breath blast and further attenuating the low frequencies. The quality, as far as could be judged from a very brief demonstration, was comparable with that of the B.B.C. type L.2 lip microphone but it was not possible accurately to assess the degree of noise suppression achieved.

4. Microphone for long-range pickup.

   The instrument displayed was a larger version of the slotted tube directional microphone of which a description has been published by Kurtze[11]. This is a development of the device produced in 1939 by Mason and Marshall[12], consisting of a bundle of tubes of graduated length, attached to a type 4017 moving-coil microphone and sometimes known, on account of its appearance, as the "machine gun". In Kurtze's invention, the bundle of tubes is replaced by a single tube, having a narrow slot running along its entire length, with a small electrostatic pressure microphone at one end. The slot is covered with fabric to give an appropriate acoustic resistance; the attenuation of sound in the slot is so graduated that the effective length of the tube is reduced at high frequencies, at which the system would otherwise be too directional.

   The directional properties of this device approximate to those of a parabolic reflector having a diameter equal to the length of the tube, in the present case, 2·3 m (7 ft 6 in.). Because of unavoidable losses in the tube, however, the axial sensitivity of the system is 6 dB below that of the bare microphone and the output would be some 20 dB below that obtainable with the same microphone using the 0·9 m (3 ft) diameter B.B.C. reflector type PRB/2. The practical potentialities of tube microphones are necessarily limited by their lack of acoustic gain; it is largely on account of this shortcoming that the "machine-gun" microphone has not found favour in the B.B.C.

5. Wireless microphone.

This is a pocket transmitter, frequency-modulated and employing a single valve together with a number of transistors. It is used in conjunction with an electrostatic microphone worn in the breast pocket. An internal ferrite aerial is used but 10 dB more gain can be obtained by the addition of an extension wire. No further details were available save that the power of the transmitter is a few microwatts and that the batteries last for four hours. The range is given as 50 m (165 ft) but the demonstration, involving transmission over distances of 30 m to 40 m (100 ft to 130 ft) was completely spoilt by ignition interference, the level of which was about equal to that of the received speech.

6. Time compressor and expander.

This device is now too well known to require a description here; the performance has been dealt with in a Designs Department report[13].

The press conference was remarkable, not only for the apparatus displayed, but for the direct and informal contact between the press and the more knowledgeable members of the technical staff.

8.3. New A.K.G. Microphones.

Three new types of cardioid microphone in course of development by A.K.G. were seen at the firm's works in Vienna.

In the first two designs, the sound admitted to the rear of the diaphragm enters by a series of apertures distributed along the direction of the microphone axis; matters are so arranged that at middle and high frequencies, only the apertures nearest the diaphragm are operative, while at lower frequencies the more remote apertures become effective. By this artifice, the difference in phase between the sound pressures acting on the front and rear of the diaphragm at low frequencies is increased; it is therefore possible without sacrifice of low-frequency response to employ an unusually stiff diaphragm and so to reduce the interference arising from mechanical vibration and wind. The principle described is not new and has already been applied by Wiggins[14] to a moving-coil microphone in which three widely separated rear apertures are provided. In the A.K.G. microphones, however, the sound enters through narrow gauze-covered slots in a delay tube leading to the rear of the diaphragm; the change in the effective length of the tube with frequency then takes place smoothly, the action being similar in this respect to that of the tube in the long-range microphone referred to in Section 8.2.

The first of the two microphones operating on the principle just described is of the electrostatic type and is designated C.27; it is roughly similar in size and shape to the familiar Philips type EL.3921/00 with the addition of the delay tube, which, widening slightly towards the rear, runs parallel with and close to the pre-amplifier housing. Prototypes have been in experimental service in the Vienna State Opera, where they can be seen in Fig. 2. The second microphone, of the moving-coil type, is known as the D.55 and is in an early stage of development; here the slotted delay tube is coiled into a spiral and thus accommodated within a cylindrical housing.

The third new cardioid microphone is the D.15, a moving-coil instrument primarily intended for close talking; this is in an advanced stage of development.

It is expected that samples of the C.27 and D.15 microphone will become available for test in the near future.

9. THEATRE EQUIPMENT.

In Vienna, the opportunity was taken to join in a conducted tour of the recently reconstructed State Opera House, which is provided with a very comprehensive electro-acoustic system for broadcasting, sound reinforcement and effects. There are two permanent control rooms, each with a window commanding a view of the stage; one of these is used for broadcasting and the other for the purposes of the theatre. It is noteworthy that apart from intercommunication apparatus, all microphones and amplifiers associated with the theatre sound system conform to broadcast standards of quality. The opera house contains a rehearsal studio fitted with sound recording equipment for both disk and tape. A reverberation room is provided for use in connection with the stage loudspeaker system.

During the tour of the opera house, a rehearsal was in progress, part of which involved the playing of musicians behind the scenes; the sound of the offstage music was being reproduced on loudspeakers mounted in the proscenium arch. The sound, heard from the back of the auditorium, was reasonably realistic; this statement must however be qualified, since the particular instrumental combination employed did not require the reproduction of frequencies much below 300 c/s and the loudspeakers referred to were not claimed to cover the full low-frequency range.

Further provision for the relaying of music is made in the form of a pipe organ installed in the rehearsal studio. Sound from this studio can be reproduced on the stage by wide-range loudspeakers of high power output; similar loudspeakers are employed for producing effects.

To enable musicians performing at remote points to follow the beat, a television camera mounted just below stage level is used to relay a picture of the conductor. In addition, the conductor's desk is provided with a set of keys, similar to the white keys of a piano, which control a remote lamp indicator flashing the numbers 1 to 4.

Permanent television equipment will eventually be installed in the opera house but at the time of the visit the work was at a very early stage.

In Hamburg, a short tour was made of the technical equipment of the State Opera House. Here it was noted that operators in the lighting gallery are given their orders by means of a small transmitter working on a frequency of about 500 Mc/s. Each operator wears on his ear a receiver consisting of a dipole, germanium rectifier and hearing-aid type earpiece; filters are used in the stage microphone circuits to avoid r.f. interference.

10. CONCLUSION.

While it would be dangerous to draw sweeping conclusions from the necessarily limited information available, the following general observations may be added to the comments already made in the course of the report.

In Germany, electrostatic microphones are employed freely in spite of their high cost — the miniature cardioid type M.59, for example, was in use at the Hamburg Musikhalle for speech reinforcement — and are considered to be quite reliable. At the same time, a considerable number of man-hours is expended on microphone maintenance, so that incipient faults may be detected at an early stage.

Germany and Austria have between them at least four firms manufacturing electrostatic microphones and two producing broadcast-grade moving-coil microphones; new designs appear on the market each year. There seems thus no lack of facilities for the commercial utilisation of any new microphone which a broadcasting organisation may develop.

Much of the equipment and methods employed in the microphone testing laboratories visited was inadequate by B.B.C. standards and it is not surprising that some of the claims for performance made by the organisations concerned have not been substantiated in this country. The fact that several continental laboratories employ similar techniques and so obtain similar results appears to have engendered in the past a false optimism which even the available aural evidence has not yet entirely dispelled.

In both Hamburg and Vienna, there appears to be very good co-operation between the loudspeaker manufacturers and the broadcasting organisation in the production of special types.

The work of the N.W.D.R. on omnidirectional loudspeakers is an interesting contribution to the art. However, in concentrating on the directional properties, the designers have tended to underrate the importance of other factors; their example, while informative, is not one to be slavishly followed.

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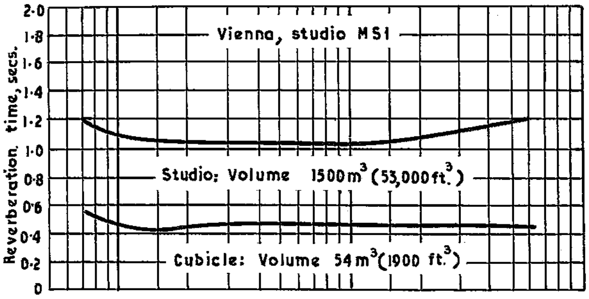
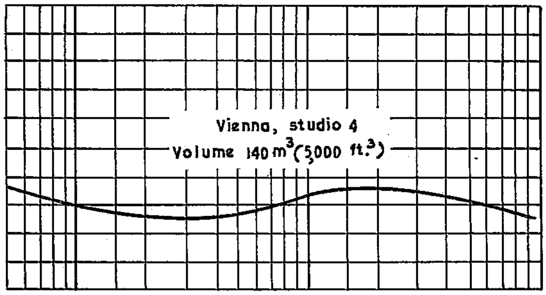
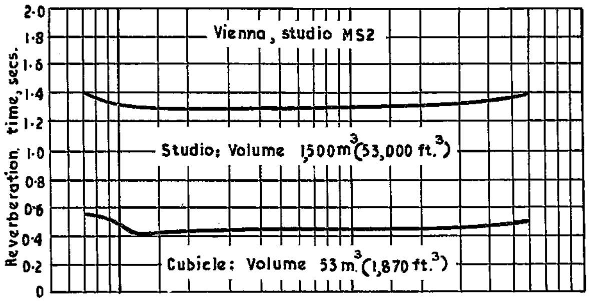
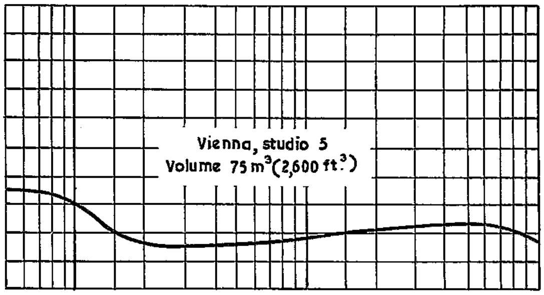
APPENDIX

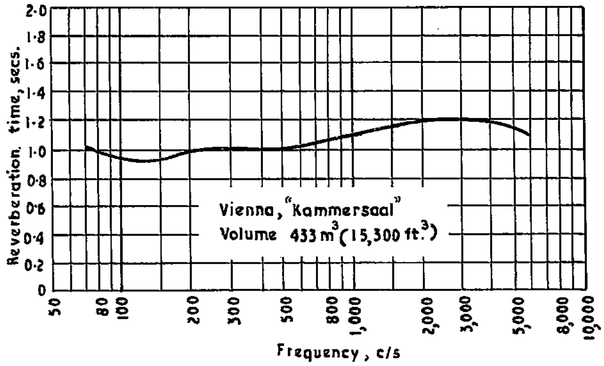
Reverberation Times of Broadcasting Studios in Vienna and Hamburg

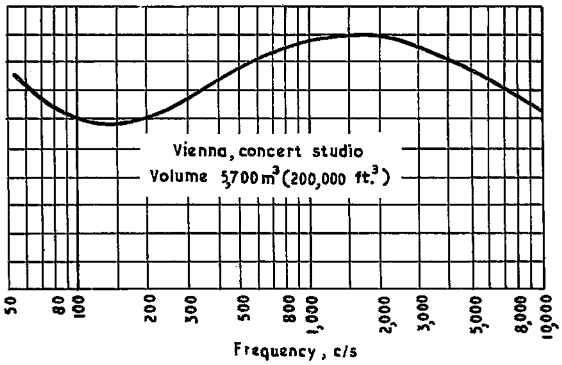


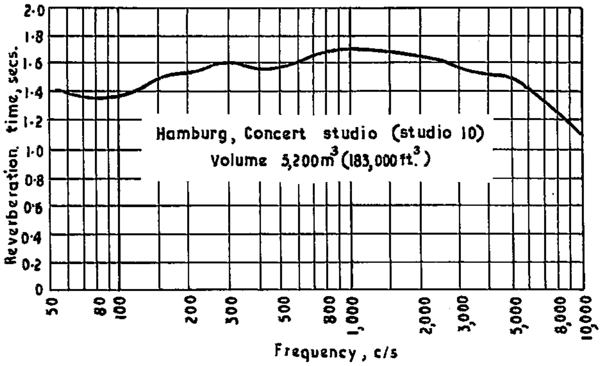












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